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RELATING FLIGHT EXPERIENCE AND PILOTS' PERCEPTIONS OF DECISION-MAKING SKILL

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Relationships between flight experience and pilots' perceptions of their ability to perform various aspects of the decision-making process were examined in the present study. Pilots were asked to rate how good they were, compared to the average General Aviation pilot, at monitoring, recognizing, diagnosing, generating solutions and implementing solutions when encountering flight path deviations, changes in weather conditions, mechanical malfunctions and conflicting traffic. Different measures of flight experience were collected. Results indicate that more experienced pilots felt that they were better at recognizing problems and implementing solutions, however, they did not necessarily feel more confident in their abilities to diagnosis the underlying causes of the problems. The results have implications for aeronautical decision making theories in general, and the design of flight training curricula in particular.

INTRODUCTION

Descriptive models of decision-making may differ in their application and goals but most share the common assumption that the decision making process consists of multiple stages or mental operations. For example, Wickens and Hollands' (2000) information processing model of decision-making and Klein's (1997) Recognition-Primed Decision-Making (RPD) model, typify the stage-like process by which decisions are made.

In general, the decision-making process begins with the perception and recognition of cues or evidence, followed by an evaluation or diagnosis of these pieces of information. A correct diagnosis of the situation is crucial as the final choice or response is based on this, and finally, the chosen course of action is carried out. The process is evaluative in nature and may begin again; actions that do not resolve the problem provide feedback and the individual changes his diagnosis and response.

Various studies suggest that experience plays an important role in decision-making and may be particularly important for diagnosis. Wickens and Hollands' (2000) model indicate that long-term and working memory exert an influence on the diagnostic stage of decision-making. Chase and Simon's (1973) classic study of expert and novice chess players suggest that working memory limitations are alleviated for the experienced individual because he/she is able to piece information together in a coherent whole compared to novices who, due to their lack of domain knowledge, are not able to do so. Similarly, Klein (1997) suggests that experts are able to make their diagnoses faster because they see "patterns" of cues, rather than separate bits of information. This advantage reduces memory load, and reduces the likelihood that the individual will succumb to cognitive biases, which have been shown to result under situations of time pressure and cognitive overload.

In addition, other studies have investigated how task experience relates to other psychological variables to improve decision-making performance. Baumann, Sniezek, and Buerkle (2001) propose a model highlighting how task experience may aid performance under conditions of acute stress. These conditions are characterized by time constraints, high levels of uncertainty, and severe consequences of failure, for example, life and death. In the model, task experience is described to increase success in performance in three ways: (1) more experienced individuals learn which strategies lead to the successful attainment of the goal, and which do not, (2) experience reduces the uncertainty with regard to the individual's expectations of success or failure in the task and this reduces level of anxiety, and (3) experience reduces the degree of ambiguity in the problem situation.

While it has been established in various domains that experience is related to task performance, two issues emerge when the role of experience is considered within the context of aeronautical decision-making. Firstly, how is experience defined within aviation and secondly, does experience relate similarly to all stages of decision-making when pilots are faced with different in-flight problems?

Measures of Flight Experience

Studies that have investigated the role of flight experience in the performance of flight-related tasks have used and shown different measures to be important. The role of experience has been examined in retrospective analyses of accident records from aviation accident databases and in empirical investigations of how pilots respond in simulations of different flight scenarios. Some of these measures include total flight hours (Goh & Wiegmann, in press; Burian, Orasanu, & Hitt, 2000; Li, Baker, Grabowski, & Rebok, 2001), cross-country flight experience (Wiggins & O'Hare, 1995), and recent experience (Goh & Wiegmann, in press; O'Hare, Owens, & Wiegmann, 2001). In addition to measures of flight hours, pilot certification (e.g., private or commercial license) and pilot ratings (e.g., instrument rating) have also been found to be crucial (Goh & Wiegmann, in press; Li et al., 2001).

The studies cited above suggest that there is no one measure of flight experience that best captures the notion of "domain specific experience" deemed to be important by various researchers in the fields of problem-solving (e.g., Chase & Simon, 1973; Chase & Ericsson, 1981) and decision-making (e.g., Klein, 1997; Baumann, Sniezek, & Buerkle, 2001). While it is relatively straightforward how experience may be measured in the contexts (e.g., chess playing, fire fighting, military) that have been investigated by these researchers, it remains ambiguous which measures of flight experience are most appropriate. It may, perhaps, be the case that certain measures of flight experience are important for certain flight tasks, but not others.

Role of Flight Experience

Another issue that needs clarification is how experience affects decision-making in a flight environment. In the investigation of weather-related decision-making, some researchers (Wiggins & O'Hare, 1995; O'Hare, Owens, & Wiegmann, 2001) have found that pilots with more experience (as measured by cross country and recent flight hours) tend to make the decision to continue flight into adverse weather, while others have found the opposite. For example, Burian et al. (2000) studied incident reports and found that pilots who were in the 25th percentile and lower in terms of flight hours were more likely to commit a plan continuation error in the context of in-flight encounters with weather, than pilots who were in the 75th percentile and higher. Apparently, experience often produces better diagnostic decision making skills, but at the same time it may also reduce pilots' perceptions of risk, particularly as it relates to adverse weather. Therefore, more experienced pilots may choose to divert a flight into adverse weather but at other times they might choose to continue. Consequently, inferring decision-making processes from behavioral outcomes can frequently produce equivocal results.

Purpose of Present Study

The purpose of the present study was to further explore these issues by assessing pilots' perceptions of their own abilities to perform different aspects of the decision-making process (e.g., diagnosing, solution generation) when confronted with different flight-related problems. Knowledge of how pilots view their own capabilities may provide insights into how experience affects aeronautical decision-making and may help explain some of the equivocal results obtained in previous behavioral decision-making studies. The results may also have implications for improving how pilots are trained in general and may provide information about the stages of decision-making in which pilots feel they particularly need more training.

METHOD

Sixty-four pilots with private pilots' licenses participated in the study. These participants were recruited from the Institute of Aviation, at the University of Illinois, Urbana-Champaign, as well as communities in the Central Illinois Region. Their ages ranged from 18 to 66 years (*Mdn* = 42), and their total flight hours ranged from 54 to 1983 hours (*Mdn* = 277.5 hrs). Twenty-three were instrument rated.

The participants were asked to fill out a pre-experimental questionnaire as part of a larger study investigating aeronautical decision-making. The pilots were required to give background information regarding their age and different measures of flight experience (e.g., total flight hours, total instrument hours, VFR cross-country hours, hours in the last 30 and 90 days). They also rated their ability to perform different aspects of decision-making, with regard to problems related to flying (e.g., navigation, weather, engines, traffic). The questions asked are shown in Table 1. The pilots were asked to provide these ratings, comparing themselves to the average General Aviation pilot, using a Likert scale which ranged from 1 to 7, with a rating of 1 being "Much Worse Than", 7 being "Much Better Than" and 4 being "Just as Good".

Table 1. Questionnaire Items

Decision Making Stage/Questions

Vigilance

- During flight, how vigilant are you that in are on the right flight path?
- During flight, how vigilant are you in monitoring weather conditions (e.g., visibility, cloud ceiling, precipitation, winds) that may affect the safety of the flight?
- During flight, how vigilant are you in scanning instruments and gauges to ensure that there are no mechanical or system malfunctions?
- During flight, how vigilant are you in scanning the outside world to ensure that there is no conflicting traffic?

Recognition

- During flight, how good are you at recognizing deviations from your flight path?
- During flight, how good are you at recognizing or detecting changes in weather conditions?
- During flight, how good are you at recognizing changes in the mechanical functioning of your plane?
- During flight, how good are you at recognizing other traffic which may come into conflict with your flight path?

Diagnosis

- During flight, how well are you able to diagnose or assess the extent to which you have deviated from your planned flight path?
- During flight, how well are you able to diagnose or estimate actual weather conditions (e.g., visibility, cloud ceiling)?
- During flight, how well are you able to diagnose problems or determine the cause of a mechanical malfunction in your plane (e.g., engine failure, insufficient fuel)?
- During flight, how well are you able to diagnose or determine the likelihood that other traffic will conflict with your flight path?

Table 1. Questionnaire Items (cont'd)

Decision Making Stage/Questions

Generation of Solutions

- In the event that you have deviated from your planned flight path, how well are you able to generate solutions to help get back on course?
- In the event that you encounter adverse weather en route, how well are you able to generate solutions or identify alternative courses of action to resolve the problem?
- In the event of a mechanical malfunction during flight, how well are you able to generate solutions or come up with ways to deal with the problem?
- In the event that you encounter conflicting traffic, how well are you able to generate solutions or identify alternative courses of action to avoid such traffic?

Implementation of Solutions

- How well can you regain your flight path if you have deviated from it?
- How good are you at avoiding flying into adverse weather conditions?
- In the case of an engine malfunction, how well are you able to perform an emergency procedure or other course of action?
- How well are you able to maneuver aircraft to avoid conflicting traffic?

RESULTS

Pilots' self-ratings of their decision-making ability were correlated with the different experience variables. Table 2 shows the results. The results indicate that the self-ratings are significantly related to experience, depending on the stage of decision-making and the type of problem. Generally, correlations between self-ratings of how vigilant the pilots are and flight experiences are close to 0 for all the flight problems. The negative correlation between self-ratings of vigilance in monitoring for conflicting traffic and total instrument flight rules (IFR) hours were marginally significant (r = -.213, p = .09); pilots who had accumulated more hours flying by instruments, rated themselves less vigilant at monitoring for conflicting traffic than those with few instrument flight hours.

Self-ratings for the recognition of problems related to the different flight tasks were generally positively correlated with some measures of flight experience. Except for recognizing deviations from the planned flight path, pilots with more experience rated themselves significantly better at recognizing problems with weather (total number of VFR cross-country flights: r = .269, p < .05), engine malfunctions (total flight hours: r = .262, p < .05; total VFR hours: r = .257, p < .05) and traffic (total VFR hours: r = .264, p < .05; total number of VFR cross-country flights: r = .312, p < .05) than those with fewer hours.

Similar to ratings for vigilance, the correlations between how well pilots thought they were able to diagnose flight problems and experience were generally close to 0. Only experience as measured by total flight hours (r = .296, p < .05) and total VFR flight hours (r = 273, p < .05) were significantly correlated with the pilot's ratings of their ability to diagnose deviations from the planned flight path. The correlation between hours flown in the previous 30 days and rating of ability to diagnose changes in weather conditions were only marginally significant (r = .227, p = .09).

The generation and implementation of solutions appears most well correlated with the measures of flight experience. Pilots who had more recent flight hours rated themselves better at generating solutions for deviations from the planned flight path, than those with less recent experience, r = .263, p < .05. The more experienced pilots (total flight hours: r = .289, p < .05; total VFR flight hours: r = .280, p < .05; total VFR cross-country flights: r = .255, p < .05; total number of VFR cross-country flights: r = .317, p < .05; hours in last 30 days: r = .267, p < .05) also rated themselves better at generating solutions to weather changes than the less experienced pilots. No statistically significant correlations were found between flight experience and ability to generate solutions to engine problems and conflicting traffic.

Pilots' ratings of their abilities to implement solutions were significantly correlated with at least one measure of flight experience, for all tasks. The number of hours flown in the last 30 days was significantly correlated with ratings of ability to implement solutions to flight path deviations (r = .295, p < .05) and engine malfunctions (r = .288, p < .05). In addition, total flight hours and total VFR flight hours were significantly correlated with ratings of ability to implement solutions when encountering adverse weather (total flight hours: r = .304, p < .05; total VFR hours: r = .280, p < .05) and dealing with conflicting traffic (total flight hours: r = .320, p < .01; total VFR hours: r = .274, p < .05).

DISCUSSION

Numerous studies have shown that domain specific experience is particularly important in the diagnostic stage of decision-making. Experience aids in reducing the load on working memory because of the more sophisticated strategies that may be used in assessing the situation. In addition, meta-cognitive influences, such as self-confidence, also affect this relationship (e.g., Dawson, 2000).

The results of the present study indicated that pilots with more experience are generally more confident of their ability to recognize problems and to generate and implement solutions. However, contrary to previous research on expertise, the results of the present study suggest that pilots with more experience do not necessarily feel more confident in their ability to diagnose flight-related problems. Perhaps, pilots are not trained as thoroughly in diagnostic decision-making processes as are experts in other domains. Indeed, pilots are generally trained to detect problems, such as engine failures, but to then rely on checklists and documented emergency procedures to diagnose and resolve the problems.

Table 2. Pearson's Correlation Between Flight Hours and Pilots' Self-Ratings of Decision-Making Ability

	Total Hours	Total VFR Hours	Total IFR Hours	Total VFR X-Country Hours	Total No. VFR X-Country	Hours in Last 30 Days	Hours in Last 90 Days
Vigilance							
Flight Path	.132	.126	.075	.070	.125	.176	.108
Weather	-.016	-.017	.026	-.097	.146	-.034	-.066
Engine	.103	.063	.013	-.001	.037	.098	.035
Traffic	.111	.121	-.213	.040	.047	-.06	-.118
Recognizing							
Flight Path	.155	.182	.120	.127	.092	.202	.172
Weather	.234	.239	.229	.190	**.269***	.236	.155
Engine	**.262***	**.257***	.077	.189	.188	.120	.094
Traffic	.213	**.264***	.113	.191	**.312***	.116	.126
Diagnosing							
Flight Path	**.296***	**.273***	.183	.086	.145	.078	.217
Weather	.091	.149	-.023	-.029	.188	.227	.142
Engine	.191	.161	.050	-.012	.045	.001	.072
Traffic	.123	.115	.087	-.022	.092	.085	.170
Generating Solutions							
Flight Path	.110	.090	.103	.069	.063	**.263***	.205
Weather	**.289***	**.28***	.208	**.255***	**.317***	**.267***	.237
Engine	.232	.172	.158	.111	.035	.246	.236
Traffic	.147	.147	.004	.056	.123	.101	.086
Implementing Solution							
Flight Path	.235	.199	.179	.143	.143	**.295***	.232
Weather	**.304***	**.280***	.232	.238	.228	-.113	-.195
Engine	.183	.106	.165	.135	.209	**.288***	.228
Traffic	**.320****	**.274***	.145	.173	.172	.213	.16

*p<.05, **p<.01. Note: numbers in bold also indicate statistically significant correlations.

Some checklist procedures may even bypass the diagnostic stage altogether and simply require an emergency landing Furthermore, air-traffic control may also be relied on to help determine and resolve navigational deviations and traffic conflicts, removing some of the burden from the pilot.

While the necessity to perform diagnostic procedures may be reduced or even eliminated for some in-flight problems, other problems such as changes in weather are still important. For example, recognizing that the weather has changed does not imply a pilot will generate the most optimal plan to deal with it. Being able to diagnose how serious this weather change is and the options available given the constraints of the situation (e.g., the weather change precludes the option of returning to the origin), are highly important. Therefore, in the event that a pilot encounters situations that are not easily defined in emergency procedures (e.g., inadvertently encountering adverse weather), the pilot will need to rely on his or her own abilities to diagnose the problem quickly and accurately. Results of the present study indicate that even experienced pilots do not have an overwhelming confidence in their abilities to accomplish this task as it relates to weather.

Another possibility is that pilots who are more experienced may be more cautious in rating their abilities to diagnose flight-related problems. These experienced pilots understand the difficulty and importance of correctly assessing flight-related problems and may therefore be more conservative in their self-perceptions of their diagnostic skills.

The finding that different measures of flight experience correlate differently with ratings of confidence in performing the various stage-task combinations, suggest that different measures of experience might be significant correlates of very specific tasks. For example, pilots with more instrument hours were less confident of their ability in monitoring for traffic; pilots who fly by instruments generally do not have the responsibility of monitoring the outside world for traffic, and this reduced sense of confidence could have been the result of a "lack of practice".

In summary, the results in the present study suggest that confidence in diagnosing situations does not necessarily come with greater flight experience and should, perhaps, be enhanced within flight-training curricula. Also, since ratings of confidence are related to experience for some tasks, any empirical investigation of the role of experience in flight tasks should take into account pilots' perceptions of their abilities to perform these tasks. These ratings may clarify the relationship between flight experience and task performance.

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